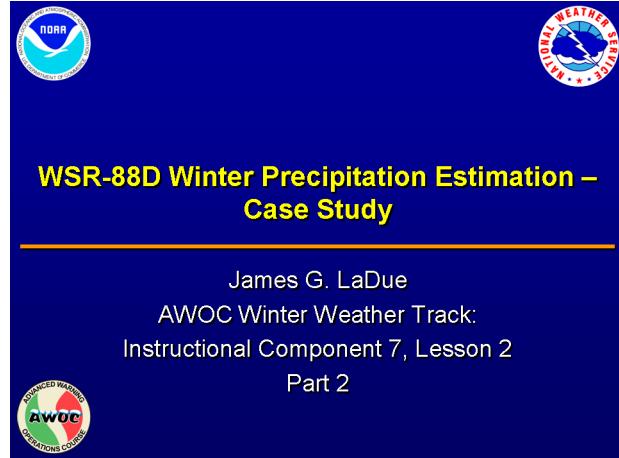

1. IC7.2 Part 2: WSR-88D Winter Precipitation Estimation - Case Study

Instructor Notes: This is part 2 of a lesson on WSR-88D winter precipitation estimation. This is a case study of a New England snow event and should last about 20 minutes.

Student Notes:



2. This Lesson

Instructor Notes: This lesson is an exercise and an extension of Lesson 2, Part 1 in IC7, titled "WSR-88D Winter Precipitation Estimation". I suggest you take lesson 2 part 1 before starting this case study.

Student Notes:

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This Lesson

- Is an exercise and an extension of Lesson 2, Part 1 in IC7, "WSR-88D Winter Precipitation Estimation"
- I suggest you take Lesson 2, Part 1 before starting this case study

3. Learning Objective

Instructor Notes: By the end of this lesson, you will understand a process to analyze the locations in the radar domain three major errors of radar derived precipitation: over-

shooting precipitation generation, overshooting sub-beam evaporation, and bright banding.

Student Notes:

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Learning Objective

- You will understand a process to analyze the locations in the radar domain three major errors of radar derived precipitation
 - Overshooting precipitation generation
 - Overshooting sub-beam evaporation
 - Bright banding

4. Performance Objectives

Instructor Notes: After completion of this lesson, you will be able to apply a methodology to analyze on a radar map three major sources of radar-based winter precipitation estimates. These error sources include: overshooting precipitation generation, overshooting sub-beam evaporation, and bright banding.

Student Notes:

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Performance Objectives

- After completion of this lesson, you will be able to apply a methodology to analyze on a radar map three major sources of radar-based winter precipitation estimates.
- These error sources include
 - Overshooting precipitation generation
 - Overshooting sub-beam evaporation
 - Bright banding

5. Review of Part 1

Instructor Notes: As a review of Part 1 of this lesson duo, remember that the radar overestimates precipitation rates where the beam overshoots evaporating precipitation and bright banding occurs. The radar underestimates precipitation where the beam overshoots precipitation production layers. There are system errors, too, that affect precipitation rate estimations such as beam blockage and calibration. You do have the option of adjusting the ZS algorithm coefficients but you would have to keep changing them over

small horizontal distances. We cannot adjust the ZS algorithm without an automated real-time correction scheme and good ground truth data. Instead we choose to draw areas where the precipitation will be over or underestimates of a fixed ZS relationship.

Student Notes:

Review of Part 1

- Radar overestimates precip rate where
 - Beam overshoots evaporating precip
 - Brightbanding occurs
- Radar underestimates precip rate where
 - Beam overshoots precip
- Other errors
 - Beam blockage
 - Calibration errors

6. Case: Range Limitations in New England

Instructor Notes: Let's try an example and take a look at how well the radar is estimating precipitation at Fitchburg, MA (in the circle). We ran the ZR algorithm using the default ZS coefficients that are planned for the Northeast U.S. and the minimum dBZ set to 10. However the results will not replicate the actual implementation of the ZS algorithm because there is no range correction applied here and a lower minimum dBZ setting. Given the criteria I set, do you think the precipitation is likely to be over or underestimated for Fitchburg?

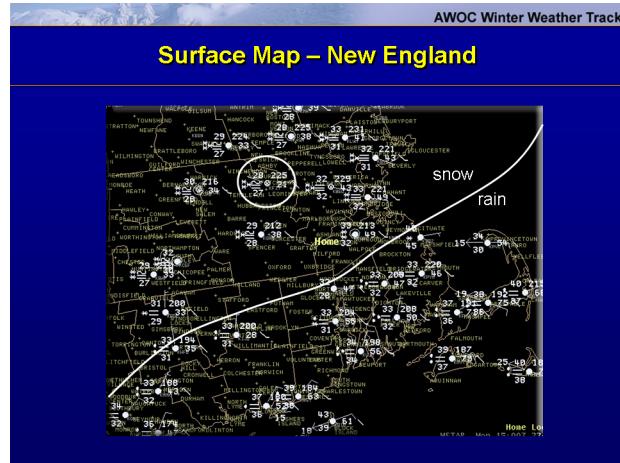
Student Notes:



7. Surface Map – New England

Instructor Notes: Fitchburg is well north of the rain snow line. The near saturation around the area also corresponds to relatively low cloud bases. Light winds in the area suggest that any bucket gauge should be able to be pretty efficient at capturing falling snow.

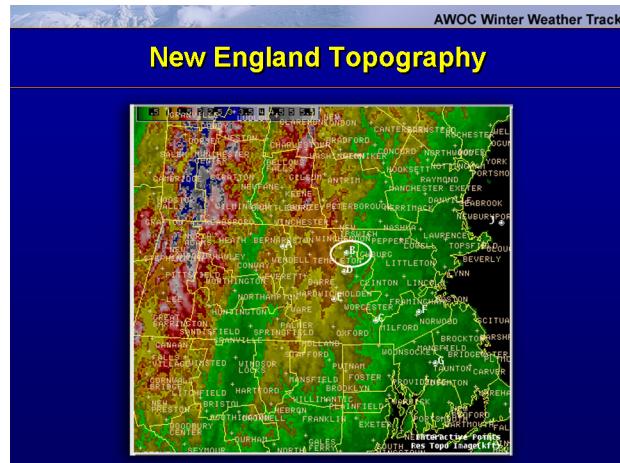
Student Notes:



8. New England Topography

Instructor Notes: Fitchburg is in an area of relatively high terrain (600' MSL) and with the light easterly winds, there should be some upslope component to the flow. Upslope flow in subfreezing air means a greater possibility of low-level feeder clouds. Let's see what the morning sounding on Cape Cod shows. Let's see what you think about the sounding with the question coming up.

Student Notes:



9. Quiz 1

Instructor Notes:

Student Notes:

10. Eta Sounding New England Case

Instructor Notes: That was a tough question. Let's assume that we need to have the lowest beam entirely below the dendrite production layer. Well, that's below about 560 mb layer or 15 kft. MSL. But it's not sufficient to be below just the dendrite production layer. We need to capture ice multiplication, aggregation, riming and needle formation. Most of these processes occur at temperatures colder than -4 degrees C. You'll need to have the beam top below 10 kft MSL to capture most of those processes. Given the deep saturated layer below, there may still be some additional aggregation as snow flakes become coated with thin films of water and get "sticky". So, reflectivity may go up a bit more. As a word of caution, thin films of water also increase the dielectric constant; therefore, reflectivity increases with no corresponding increase in actual liquid precipitation rate. Also, this sounding is not quite as far north as Fitchburg so the cold precipitation generation layer may be a little bit lower.

Student Notes:



11. Calculate Elevation of the 0.5 Degree Beam Top

Instructor Notes: It is difficult to tell where in the sounding precipitation generation ceases and precipitation falls to the ground in its final form and intensity. We do know that below the dendrite production zone, frozen precipitation continues to develop. Even in warmer temperature you still have needle formation, riming and aggregation. We'll take temperatures warmer than -4 to -5 degrees C to be the point where most frozen precipitation growth will have already occurred. The soundings in the previous page show that temperature to be roughly 7400' MSL. We'll take that height and use the beamwidth tool.

Student Notes:

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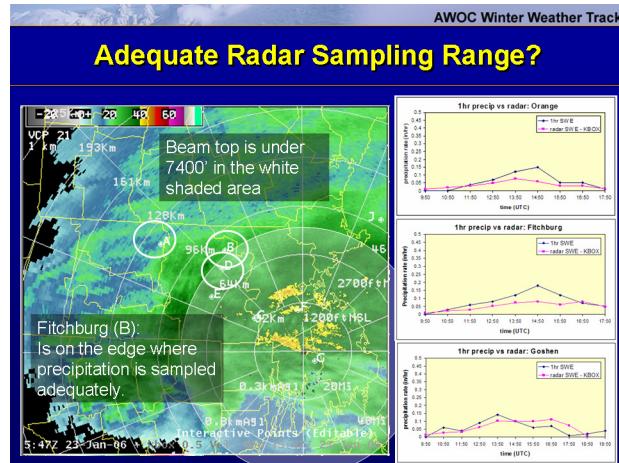
Calculate Elevation of the 0.5° Beam Top

- We will use 7400' as the top of the beam where it reaches above the LCL in -4° C temperatures for the cooler area near Fitchburg
- Click on the link button below or enter <http://wdtb.noaa.gov/tools/misc/beamwidth/index.htm>
- You'll have to modify the range until the beam top reaches 7400' for 0.5° beam angle.
- What is the range?

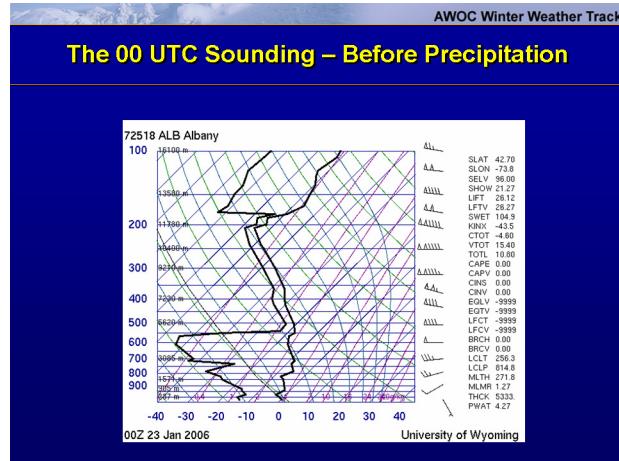
□

12. Adequate Radar Sampling Range?

Instructor Notes: It would be ideal if the beam was hugging the ground and there was no ground interference. Instead, it appears that perhaps we can adequately sample most precipitation if the entire beam remained below 7400' AGL. The white shaded circle satisfying this condition extends out about 53 nm from the radar. The Fitchburg observation is right on the outer edge of good radar sampling. Is 7400' AGL enough or do we need to be lower? As it turns out, the Fitchburg ASOS is reporting higher hourly precipitation rates than the radar using the $Z=120S^{2.0}$ relationship. Going to the town of Orange, MA, which is further away, the same problem reveals itself. The radar is underestimating the hourly reports. Going a little closer to the town of Goshen, MA, the comparison is different. The radar is showing better agreement, perhaps even a bit of an overestimate. If we believe the surface COOP station, then the radar beam is more accurately sampling the precipitation at Goshen than at Fitchburg. That is quite possibly because the beam is extending above some significant precipitation generation as one goes to Fitchburg and points beyond relative to the radar. I could make the argument that the COOP station is underestimating its precipitation and that would be a valid argument. However, I will show later in this lesson that there is nothing indicating that there is enough instrument error to change the conclusions that the radar beam over Fitchburg and beyond is overshooting generating precipitation.

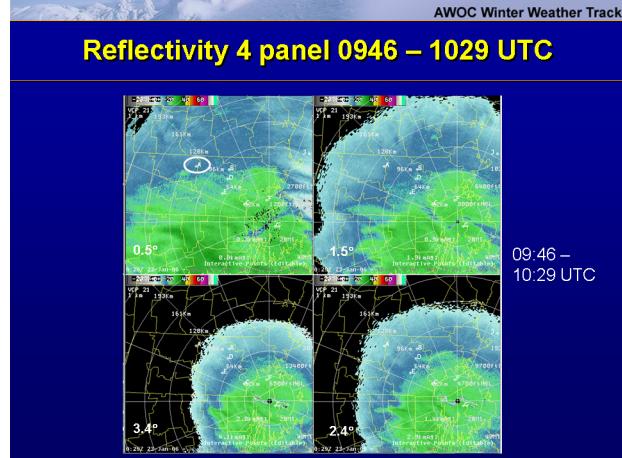
Student Notes:**13. The 00 UTC Sounding – Before Precipitation**

Instructor Notes: At 00 UTC on the 23rd, the Albany, NY sounding showed a very dry airmass below the midlevel moisture streaming in ahead of a short-wave trough. Let's take a look at the radar 4-panel image next.

Student Notes:**14. Reflectivity 4 panel 0946 – 1029 UTC**

Instructor Notes: Take a look at this loop and given the previous sounding and the nature of the reflectivity echoes, determine the type of radar-based precipitation error you may observe here. Orange, in the white oval, is reporting a 9 degree dewpoint depression. I'll pop up a quiz page next so you may answer.

Student Notes:



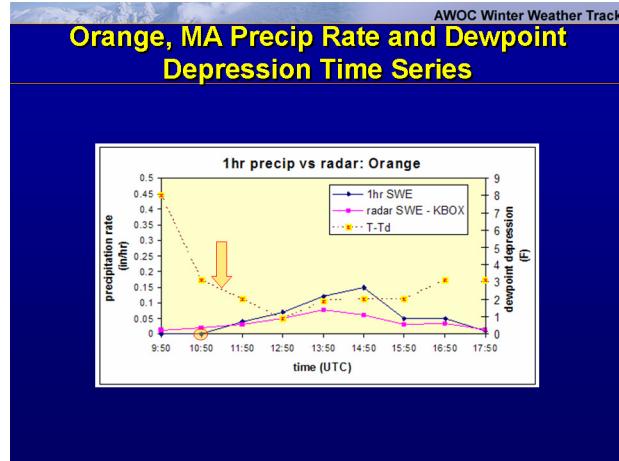
15. Quiz 2

Instructor Notes:

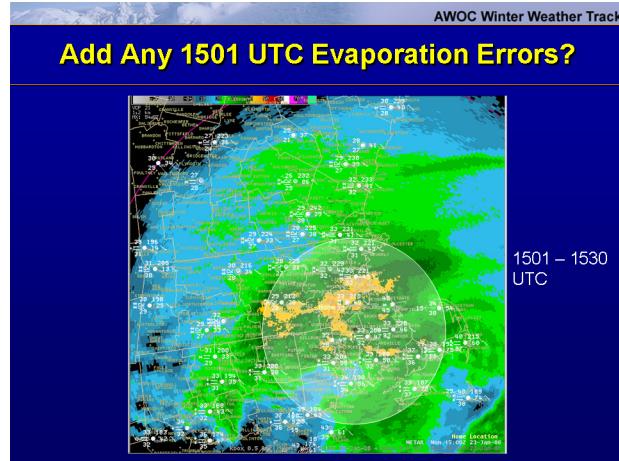
Student Notes:

16. Orange, MA Precip Rate and Dewpoint Depression Time Series

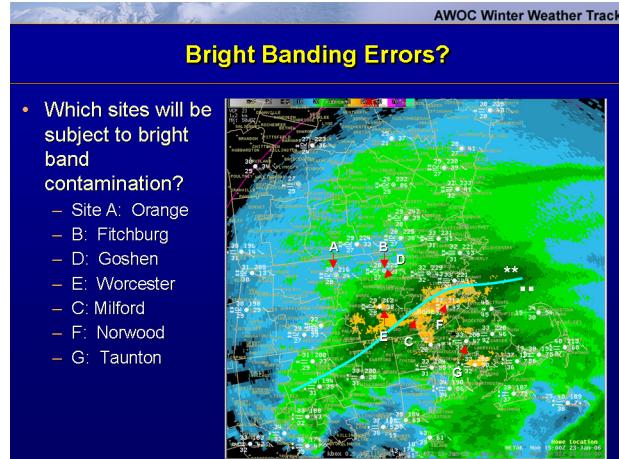
Instructor Notes: When you look at the dewpoint depressions, the dewpoint depressions correlate well with the propensity of the KBOX radar to overestimate precipitation rate at Orange. We're using Z=200S2, but we could raise the coefficient to 220 or 230 and I bet that wouldn't help because no precipitation is being recorded at Orange. Even if there was, note how the errors switch signs later on. You'd have to adapt by changing the ZS coefficients again. The error sign flipped as a large flux in moisture from above quickly saturates the air at Orange. I believe this is a common evolution for many sites that are located well away from the nearest radar.

Student Notes:**17. Add Any 1501 UTC Evaporation Errors?**

Instructor Notes: At this time, most everyone's saturated (at least with respect to ice). I doubt sub-beam evaporation is an issue now. Let's not include it in our considerations. So we still consider where the radar may overshoot precip outside the white shaded circle.

Student Notes:**18. Bright Banding Errors?**

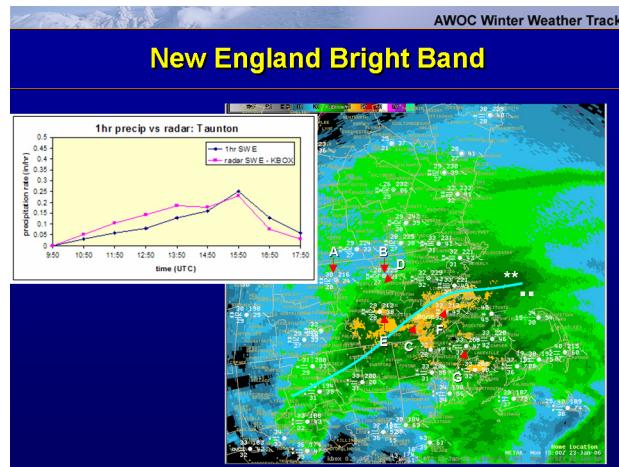
Instructor Notes: Let's try out your skill at locating bright band contamination. I have seven sites, some are ASOS, some are COOP sites. I am going to trust these sites as being relatively accurate. Understand that ASOS buckets are heated with poor shielding so some losses may occur due to evaporation and wind. Fortunately the wind is light and temperatures are fairly warm so it won't take much to melt snow into the bucket. The METARS tell me that the rain/snow line should be along the blue contour. The sites are, Orange, Fitchburg, Goshen, Worcester, Milford, Norwood, and Taunting. We'll go to a quiz.

Student Notes:**19. Quiz 3****Instructor Notes:****Student Notes:****20. New England Bright Band**

Instructor Notes: Let's go through the answer to the last question. We start off with Orange (A) and see the problems with underestimation because of overshooting. The same goes with Fitchburg (B). When we get to Goshen (D) we see the radar transition from underestimate to overestimate around 15 UTC. It could be either wet snow, sub-beam evaporation, change in precipitation particle shapes, or an error with the gauge. If we just talk about adequate precipitation coverage, it is doubtful there is sub-beam evaporation given the saturated conditions. I suggest that we are looking at wet snow aggregates with a larger than normal reflectivity factor than the liquid equivalent present. In other words, perhaps some bright banding is beginning even though it is all snow. Going to Worcester (E), shows the same effect and here it is also snow. Recall from lesson 1 that snowflakes near freezing often have a thin film of liquid resident on the ice surfaces resulting in a high dielectric constant and a high radar reflectivity cross-section. Going to

Milford (C), and especially Norwood (F), we are looking at large waterlogged flakes with a huge reflectivity cross-section as the melting layer is fully sampled by KBOX. Finally, the radar is sampling completely melted precipitation at Taunton and there is better agreement there. Note, though, that earlier in the day there is some potential bright banding.

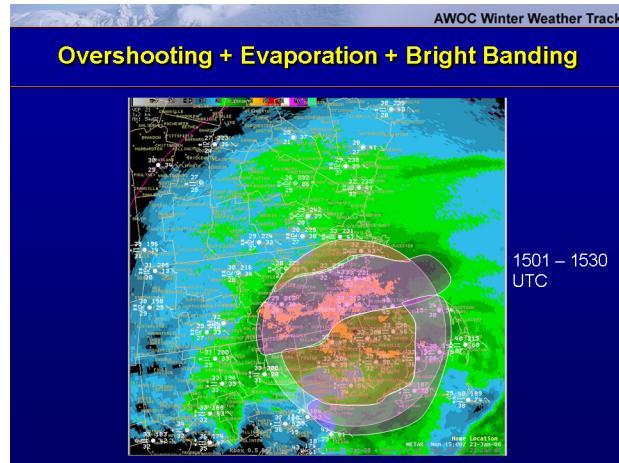
Student Notes:



21. Overshooting + Evaporation + Bright Banding

Instructor Notes: Beam overshooting problems exist outside the white shaded circle. There are likely no significant evaporation errors given the saturation across the radar domain. The most likely areas of bright banding appear in purple. The northern area is where the rain snow line exists at the surface but the errors leach into the wet snow areas to the north. Thus, the only areas of good precipitation sampling most likely exists in the orange areas. The northern orange area is the only area where snowfall is adequately sampled for the 15 UTC time frame.

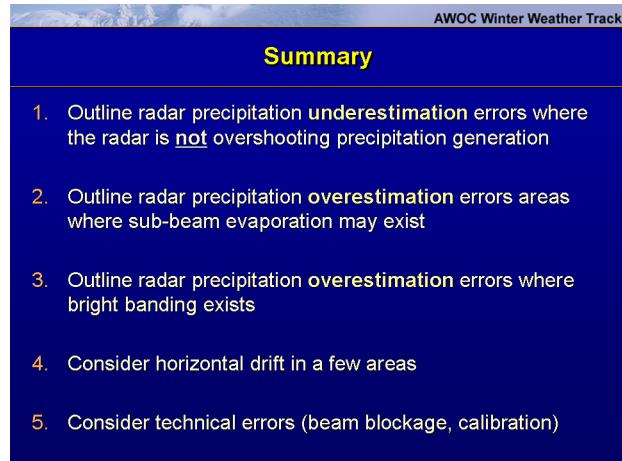
Student Notes:



22. Summary

Instructor Notes: Outline radar precipitation underestimation errors where the radar is not overshooting precipitation generation. Outline radar precipitation overestimation errors areas where sub-beam evaporation may exist. Outline radar precipitation overestimation errors where bright banding exists. Consider horizontal drift in a few areas. Consider technical errors (beam blockage, calibration). Precipitation particle shape and density is the final error source that cannot be directly accounted for except when after considering the first 5 errors. If there is a consistent bias in the precipitation where sampling is good, you may consider the ZS algorithm coefficient to be in error because of precipitation particle shape.

Student Notes:



23. Have any Questions????

Instructor Notes: If you have any questions about this lesson, first ask your local AWOC facilitator. If you need additional help, send an E-mail to the address provided. When we answer, we will CC your local facilitator and may consider your question for our FAQ page. We strongly recommend that you take the exam as soon as possible after completing this lesson.

AWOC Winter Weather Track FY06

Student Notes:

The screenshot shows a slide titled "AWOC Winter Weather Track FY06". At the top right is a small image of a snowy landscape. Below the title, a blue banner contains the text "Have any Questions?????". The main content area has a white background with a dark blue sidebar on the right. It includes a question about local facilitators, an email address for instructors, and a recommendation to take the exam soon after completing the lesson.

AWOC Winter Weather Track

Have any Questions?????

If you have any questions about this lesson:

1. First ask your local facilitator (i.e., SOO)
2. If you need additional help, send an e-mail to icwinter7@wdtb.noaa.gov (Instructors group – answers will be CC'd to your local facilitator and considered for the FAQ page)

We recommend that you take the exam as soon as possible after completing this lesson!

Warning Decision Training Branch